CHAPTER 6

ELECTRICAL CONTROLS

6-1. General electrical controls

Automation of facilities, along with technically advanced control equipment capabilities, have driven extensive use of sophisticated electrical control systems. Control systems, such as those associated with building automation, process control, and electrical system controls, are being relied on to maintain the integrity of site operations and missions. Common duties of electrical control systems include performing automatic functions; monitoring equipment status; indicating trouble conditions; recording events; generating reports; and indicating maintenance functions.

6-2. Major components of an electrical control system

Controls are broadly defined as the methods and means of governing the performance of any electric apparatus, machine, or system by sensing any need for a change and facilitating that change. In performing these duties, control circuits or systems may act to regulate, protect, indicate, open, close, or time an operation. Control devices execute control functions. Some of the more common control devices are switches, push buttons, circuit breakers, contactors, lights, rheostats, timers, alarms, batteries, coils, fuses, relays, solenoids, surge capacitors, lightning arresters, and transformers. Other special electrical equipment may be used also.

a. Generator controls. Switchgear and related control panels contain complete controls for all functions of the auxiliary generator equipment. Control for voltage regulation; phase adjustment; current compensation; engine operating parameters as well as engine start, stop, and running speed; battery charging; and brightness or dimming of indicator lights are usually provided.

b. Indicating devices. White indicating lamps with colored caps are used to show breaker positions. Green lights indicate open breakers; red lights indicate closed breakers. White lights, when used, are energized from potential transformers to indicate live circuits. Some stations include amber or orange lights to indicate that the circuit has been tripped automatically. Low voltage lamps, connected in series with appropriate resistors, are usually used to reduce lamp size and glare. Red and green lights are usually wired so that they are energized through the trip coil of the breaker. An opening in the trip coil circuit is indicated by a dark unlit lamp. Similar indicating lamps and colored caps are used to indicate normal and abnormal conditions for other control functions of the system.

c. Device characteristics. Electromechanical controls are operated by magnets, thermal action, motors, or other mechanical or static actions. Solid-state controls perform similar functions to electromechanical controls, but their characteristics are affected to a much greater degree by ambient temperature changes and excessive electrical circuit parameters.

d. Power sources. Control equipment may be powered from storage batteries or from an alternating current (AC) source. Controls will only be as dependable as their operating input. The power supply must be as reliable as possible, so that control and protection of the equipment is not jeopardized.

e. Electronic loop controls. Pneumatic and electromagnetic (EM) controls are gradually being replaced by electronic loop controls, as systems are increasingly being incorporated into energy management control systems (EMCS) or supervisory control and data acquisition systems (SCADA). Sensors are used to provide units of information via conventional (hard) wiring to the field interface devices (FID). A sensor is installed as a component part of the electrical apparatus being controlled and must be maintained by electrical maintenance personnel. Control line components such as FIDs, data transmission links, the central processing unit (CPU), and its subcomponents are not electrical maintenance responsibilities. Communications lines are used, such as telephone pairs; coaxial cable; radio, micro-wave or power line carrier signals; and fiber optics, sometimes as a part of a local area network (LAN).

f. Relays. A relay is an electrical device designed to interpret input data in a prescribed manner. When specific input conditions occur, the relay responds to cause contact operation or a similar sudden change in associated electric control circuits. Input data analyzed is usually electrical, but may be mechanical or thermal, or evaluate other conditions or a combination of conditions. Electrical conditions can be overcurrent, overvoltage or undervoltage, a combination of current and voltage, current balance, direction of current flow, frequency, impedance, or other electrical data.

(1) Electric power apparatus relays and relay systems are designed to operate circuit breakers and contactors, usually medium-voltage units. Electric power apparatus relays operate to quickly sense problems and speedily isolate power systems under fault conditions. Such an action limits the extent of electrical equipment damage and provides a means to limit outage periods.

(2) Industrial control relays are designed primarily for industrial control, for switching of communication or other low-level signals, or for any other equipment not controlling electric power apparatus.

(3) Relays can be classified by functions, input operating principals, and performance characteristics. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE) C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus (1994), covers classifications of relays and also standard service conditions, ratings, tests, and temperature rise.

(4) Relays are classified according to their primary purposes, which are protective, regulating, monitoring, programming, and auxiliary control. Some relays may qualify for more than one classification, depending on their application. Input relays are classified as such because the relay responds to a signal input of either voltage or current. Relays are also classified in accordance to their operating principles or structural features, such as electromechanical or solid-state types.

g. Relay functions. Relays are selected to perform certain functions. To standardize on reference use, they are given device function numbers by ANSI/IEEE C37.2, Standard Electrical Power System Device Function Numbers and Contact Designations (1996). (Device function numbers also describe other electrical power apparatus equipment in addition to relays.) Device function numbers readily identify devices in drawings, diagrams, instruction books, publications, and specifications. The use of “52” for circuit breakers, “51” for an AC time overcurrent relay, “65” for a governor, and “86” for a lockout relay provide a simple brief AC method of designation of the device’s operational performance. The standard also covers suffix letters used for main devices (such as “N” for neutral), actuating qualities (such as “A” for amperes), auxiliary devices (such as “CS” for control service), operating device components (such as “TC” for trip coil), and auxiliary contact positions (such as “a” and “b”, “aa” and “bb”).

(1) Instantaneous relays act on an EM attraction operating principle wherein a plunger, solenoid, hinged armature, or balance beam is pulled into a coil or pole face of an electromagnet. They can be used in both AC and direct current (DC) power systems.

(2) Time-delay relays act on an EM induction operating principle, whereby torque is developed in a movable rotor (disc or cup) which rotates between two faces of an electromagnet. These units can only be used in AC circuits. Time overcurrent and time under/overvoltage relays are generally of the disc design type, while high-speed overcurrent, directional, differential, and distance relays are more often of the cup (cylinder) design type.

(3) Solid-state relays are extremely fast in their operation, as they have no moving parts. Other advantages are lower burden, high seismic-withstand, and reduced panel space. Many are programmable, allowing increased choices of time-current characteristics. There are no formal statistics available, but estimates are that 40 to 50 percent of relays sold in 1992 were solid-state units. Today it is estimated that 85 to 95 percent are the solid-state type. Solid-state relays require no preventive maintenance, but they do require a periodic maintenance check.

(4) Protective relays detect, isolate, and/or indicate abnormal electrical conditions. The operation of circuit breakers or other protective devices is initiated by relays as required. Some of the electrical hazards protected against are short circuit, overcurrent, overvoltage, undervoltage, and phase or frequency irregularities. Relays installed to protect generator stator windings from internal shorts and overheating are sensitive to faults in the generator and do not respond to faults outside the generator. These relays act rapidly to prevent damage to the generator and isolate the generator from the system. Relay action includes de-energizing the generator field winding. Protective relays are provided in systems when reverse power flow occurs. Those relays operate on a succession of power reversals and current impulses to detect loss of synchronism.